JAPAN

EDICT OF GOVERNMENT

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JIS Z 4333 (1990) (English): Portable photon ambient dose equivalent ratemeters for radiation protection

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The citizens of a nation must honor the laws of the land.

Fukuzawa Yukichi

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JAPANESE INDUSTRIAL STANDARD

Portable Photon Ambient Dose Equivalent Ratemeters for Radiation Protection

JIS Z 4333—1990

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JAPANESE INDUSTRIAL STANDARD J I S

Portable Photon Ambient Dose Equivalent Ratemeters for Radiation Protection

Z 4333-1990

1. Scope

This Japanese Industrial Standard specifies portable photon ambient 1 cm dose equivalent ratemeters for radiation protection (hereafter referred to as the "ratemeter").

Remark: The units and numerical values given in { } in this Standard are based on the traditional units and are currently the criteria in force.

Informative Reference: This Standard is only to standardize persistently ratemeters and does not mean that it is required to use ratemeters for radiation control.

2. Definitions

For the purposes of this Standard, main definitions are in accordance with JIS Z 4001, JIS Z 4511 and JIS Z 8103 and to others the following apply:

(1) 1 cm dose equivalent When irradiating ICRU ball by X-rays or γ-rays of broad beam in a single direction, the dose equivalent in depth of 1 cm on main axis from the surface of incidence along the incident direction.

(2) ICRU ball A ball having the element composition shown in Report 39 of the International Commission on Radiation Units and Measurement (ICRU) (In mass percentage, oxygen 76.2 %, carbon 11.1 %, hydrogen 10.1 and nitrogen 2.6 %), of 1 g/cm^3 in density and 30 cm in diameter.

Applicable Standards:

JIS Z 4001-Nuclear Energy Glossary

JIS Z 4511-Methods of Calibration for Radiation Exposure Meters and Radiation Exposure Rate Meters

JIS Z 8103-Glossary of Terms Used in Instrumentation

Reference Standards:

JIS Z 4328-Radiation Survey Meters for X and γ Rays

JIS Z 4332-General Requirements for Personal X-and γ-ray Dosemeters

(3) indicating value The value of 1 cm dose equivalent indicated by ratemeter.

(4) decade The unit indicating the scale range of logarithmic scale or equivalent scale thereto (hereafter referred to as the "logarithmic scale"). For example, when the common logarithm of ratio of two scale values is A, the scale range between two scales is taken as A decade.

(5) response The value of indicating value divided by 1 cm dose equivalent to be reference (hereafter referred to as the "reference dose equivalent"). This is the inverse number of calibration constant.

(6) coefficient of variance (C) The ratio of estimated value (S) of standard deviation of n pieces of measured value (x_i) to average value ($\bar{x}$) and it is in accordance with the following formula:

$$C=\frac{S}{\bar{x}}=\frac{1}{\bar{x}}\sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(x_i-\bar{x})^2}$$

(7) effective energy Relating to X-ray of not single energy, the energy of single energy photon having the equivalent half-value layer thereto. Herein, the half-value layer means the thickness of filter paper required for reducing the exposure rate to half by measuring under narrow beam conditions.

3. Classification

Ratemeters shall be classified according to detector used into ionization chamber type, GM counter tube type scintillation type and semiconductor type.

4. Performance

4.1 Indication Error When tested accoriding to 6.2.2, the following specifications shall be satisfied.

(1) In the case of linear scale, either one of the percentage to the reference dose equivalent or the percentage to the maximum scale value shall comply with the permissible range shown in Table 1.

Table 1. Permissible Range of Indication Error in the Case of Linear Scale

Unit: %

Classification	Permissible range of percentage to reference dose equivalent	Permissible range of percentage to the maximum scale value
Ionization chamber	± 10	± 5
GM counter tube type Scintillation type Semi-conductor type	± 20	± 6

(2) In the case of logarithmic scale, it shall comply with the permissible range shown in Table 2.

Table 2. Permissible Range of Indication Error in the Case of Arithmetric Scale

Classification	Permissible range decade
Ionization chamber type	± 0.04 x N
GM counter tube type	± 0.06 x N
Scintillation type	
Semi-conductor type	

Remark: N indicates the number of decades of its indication range.

(3) In the case of digital type, it shall comply with the permissible deviation shown in Table 3.

Table 3. Permissible Range of Indication Erron in the Case of Digital System

Classification	Permissible range %
Ionization chamber type	± 10
GM counter tube type	± 20
Scintillation type	
Semi-conductor type	

4.2 Energy Characteristics When the energy characteristics are expressed by energy dependence of response and tested according to 6.2.3, the ratio of γ rays of ^{137}Cs to response shall comply with Table 4.

Table 4. Permissible Range of Energy Dependence

Classification	Energy range	Permissible range of ratio of response
Ionization chamber type	30 keV to 1.5 MeV (30 keV to 6.5 MeV)*	0.8 to 1.2 (0.7 to 1.2)*
GM counter tube type	60 keV to 1.5 MeV	0.5 to 2.5
Scintillation type	60 keV to 1.5 MeV	0.2 to 5.0
Semi-conductor type	80 keV to 1.5 MeV (80 keV to 6.5 MeV)*	0.7 to 1.3 (0.5 to 1.3)*

Note * Numerical values in parentheses are the preferable value as the permissible range when obtained the ratio of response relating to energy range up to 6.5 MeV by using γ rays of ^{16}N, but these are reference values and are not a part of Standard.

4.3 Directional Characteristics When the directional characteristics are expressed by irradiation direction dependence of radiation in indicating value to detect in part, and tested according to 6.2.4, the permissible range of direction dependence shall be ± 20 %. However, the direction dependence to X-rays near 80 keV in effective energy or to γ rays of ^{241}Am shall be reference and does not specify the tolerance.

4.4 Variation of Indicating Value When tested according to 6.2.5, the coefficient of variance shall comply with Table 5.

Table 5. Permissible Values of Coefficients of Variance

Ionization chamber type	GM counter tube type	Scintillation type	Semi-conductor type
0.10 max.	0.15 max.	0.10 max.	0.15 max.

4.5 Response Time When tested accoriding to 6.2.6 the response time shall be not more than 30 s.

4.6 Drift When tested according to 6.2.7, the variation of indicating value shall be ± 2 % in the case of analog system, and not more than three digits in the case of digital type.

4.7 Over-Scale Characteristics When tested according to 6.2.8, in the case of analog system, the position of pointer shall indicate the outside of scale range of high dose rate side. In the case of digital system, it shall indicate over-scale by flashing of display lamp or the like.

4.8 Temperature Characteristic When the temperature characteristic is expressed by temperature dependence of indicating value and tested according to 6.2.9, it shall comply with Table 6.

Table 6. Permissible Ranges of Temperature Dependence

Temperature range °C	Permissible range %
5 to 35	± 10
-5 to 45	+ 20

4.9 Moisture Resistance When tested according to 6.2.10, the variation of indicating value shall be ± 10 %.

4.10 Stability Against Fluctuation of Power Source Voltage When tested according to 6.2.11, the fluctuation of indicating value shall be ± 5 %.

4.11 Impact Resistance When tested accoriding to 6.2.12, the result shall satisfy 4.1.

5. Structure

5.1 Structure General The structure shall comply with following each item.

(1) The construction shall be such that the detector, indicating device, and power source are constructed to be integral or connected by cables, to be convenient for operation and transporting and when placed it is good and rigid in stability.

(2) 1 cm dose equivalent (unit: mSv/h or the like) can be indicated directly.

(3) It is difficult to receive influences of vibration, shock, electromagnetic environment, etc.

(4) As required, output terminal for recorder, output circuit of alarm signal, etc. may be provided.

(5) It may be made such structure that a window for incidence of β rays at the detecting part and particle flux density of β rays and the like can be measured.

(6) A circuit capable of measuring integrating value of 1 cm dose equivalent may be attached.

(7) As required, a radiation source for sensibility test can be attached.

Remark: In the case where radiation source for sensibility test (hereafter referred to as the "radiation source for test") is attached, the following conditions shall be complied.

(1) The radiation source for test shall be ^{137}Cs or ^{226}Ra, and the scaled radioactive material less than the quantity specified in article 1 clause 3 of "matters to determine quantity of isotope to discharge radiation (Notification No. 15 of Science and Technology Agency on 1988, 5, 18)" shall be used.

(2) The radiation source for test shall be described with the nuclide name, 1 cm dose equivalent indicating value when it is used according to the specific method and year and month when it is confirmed.

5.2 Indicating Device The indicating device shall be linear scale or graduated to logarithmic scale or be digital marking.

5.3 Power Source The power source shall comply with following each matter.

(1) The power source shall be battery type and may be the system to use in combination the a.c. power source (rated voltage: 100 V, frequency: 50 Hz or 60 Hz).

(2) It shall have function capable of checking easily the degree of consumption of battery for power source.

(3) In the case where the ratemeter is used continuously according to the battery designated by manufacturer, it shall be of such structure that the performance specified in 4.1 can be maintained for not less than 100 h. However, in the case of charging type, it shall be not less than 10 h.

6. Tests

6.1 Test Conditions

6.1.1 Common Test Conditions In each test method of 6.2, relating to test conditions not particularly specified, those shall be in accordance with Table 7.

Table 7. Common Test Conditions

Item		Condition
Circumferential temperature	°C	20 ± 5
Relative humidity	%	65 ± 20
Atmospheric pressure	kPa {mbar}	101.3 ± 5.0 {1013 ± 50}
Power source voltage	V	Rated voltage ± 5 %
Dose equivalent of test environment	μSv/h	< 0.25
Irradiation direction of radiation		Direction designated by manufacturer ± 5°

6.1.2 Calibration Apparatus For test, the following calibration apparatus in which the tracability with the radiation dose standard specified in JIS Z 4511 is clear shall be used.

(1) The calibration apparatus for X-rays shall be the X-ray irradiation appartus of which irradiation dose (rate) is measured by an irradiation dose (rate) measuring device in which the tracability with irradiation dose standard is clear.

(2) The calibration apparatus for γ rays shall be the γ-ray irradiation apparatus of which irradiation dose (rate) is measured by an irradiation dose (rate) measuring device in which the tracability with irradiation dose standard is clear or be reference γ-ray source.

6.2 Test Methods

6.2.1 Test Method General The test method general shall be as follows:

(1) Execute all tests after lapse of time of preheating for 5 min.

(2) In the case where the test is carried out with varying a certain item condition out of test conditions, other conditions than the item shall be in the range of permissible width of Table 7.

(3) Obtain the 1 cm dose equivalent by multiplying the exposure rate by conversion factor shown in Attached Table corresponding to photon energy or effective energy.

(4) For indicating value, in the case of carrying out the test according to calibration apparatus, use the value subtracting by background and do not contain the error of reference dose equivalent in indicating error.

(5) For test results in the case of digital system, exclude the digital error.

(6) Unless particularly specified in each test method, let the γ-ray source to be used be, as rule, ^{137}Cs ray source.

6.2.2 Indicating Error Test The indicating error test shall be carried out by using a γ-ray irradiation apparatus or reference γ-ray source according to the method shown in the following.

(1) In the case of linear scale, relating to at least one measuring range, and relating to indicating values respectively near 20 %, 50 % and 80 % of the maximum scale value, and further relating to other all ranges, relating to indicating values near 80 %, obtain the percentages of indicating value subtracted by reference dose equivalent relative to reference dose equivalent and to the maximum scale value.

(2) In the case of logarithmic scale, obtain the common logarithm of indicating value divided by reference dose equivalent relating to indicating values near 0.5 and 1.0 decade for each decade.

(3) In the case of digital system, obtain the percentage of indicating value subtracted by reference dose equivalent to reference dose equivalent relating to indicating values near 50 % and 100 % of each decade relating to all measuring ranges.

6.2.3 Energy Characteristic Test Carry out the energy characteristic test by means of irradiation apparatus or reference γ-ray source of ^{137}Cs and ^{60}Co as well as X-ray irradiation apparatus. Obtain the response to each photon energy or each effective energy and obtain the ratio of response to each energy when taking response of ^{137}Cs as 1.

Further, in the case where the sufficient indicating value is able to be obtained by ^{241}Am, ^{57}Co and ^{133}Ba reference γ-ray sources, instead of X-rays, γ-rays from these ray sources may be used.

6.2.4 Directional Characteristic Test Taking the irradiation direction of radiation designated by manufacturer as 0°, irradiate the radiation from 0° relating to two planes of horizontal and vertical planes including that direction, respectively from directions of 30°, 60° and 90° in right and left, and up and down and read out the indicating value. However, in the case where the detector is cylindrical type and the direction designated by manufacturer is central axis directrection, take one arbitrary plane including the central axis.

Further, when 90° direction becomes cable side, exclude this direction.

In the case of detector-built-in type, carry out the test relating to 75° instead of 90°.

Take the value of 0° direction as reference value, and obtain the percentage of indicating value to each direction subtracted by reference value relative to the reference value.

Furthermore, also relating to X-rays near 80keV in effective energy or γ-rays of ^{241}Am, carry out the directional characteristic test according to the similar method.

6.2.5 Indicating Value Fluctuation Test Irradiate γ-rays of 1 cm dose equivalent corresponding to the indicating value shown in the following, read out the indicating values at least 20 times at time intervals to be able to be considered independent statistically (approximately 1.5 times the response time) and obtain the coefficient of variance according to the formula of 2. (6).

(1) In the case of linear scale, take the indicating value of 30 to 50 % of the maximum scale value in the maximum sensitivity indicating range.

(2) In the case of logarithmic scale, take the indicating value of 0.3 to 0.5 of the minimum decade.

(3) In the case of digital system, take 30 to 50 digits under the measuring condition of highest sensitivity.

6.2.6 Response Time Test Vary the 1 cm dose equivalent to ratemeter rapidly, and when the indicating value becomes N' from N, measure the time required for indicating value to become the value shown by the following formula from N.

$$N+0.9\ (N'-N)$$

Carry out the measurement relating to cases of increasing the indicating value and of decreasing that and carry out at 1 cm dose equivalent for $\frac{N'}{N}$ to become 10 or more in the case of increasing and for $\frac{N}{N'}$ to become such in the case of decreasing.

6.2.7 Drift Test In an environment little in fluctuation of natural radiation, place a ratemeter in a sealed body by lead of 50 mm or more in thickness and make the working condition.

In the case of analog system, connect the indicator output with the recorder of linear scale. Relating to the highest sensitivity indicating range of ratemeter, align the base point of scale and the maximum scale value with zero and full scale of recorder. In the case where the indicating value is not more than 10 %, regulate the pointer of recorder at nearly 10 % and record for 4 h. Relating to the central value of statistic fluctuation of this record, take the initial value as the reference value, and obtain the percentage of the maximum deviation (either positive or negative) from the reference value to the full scale.

In the case of digital system, record the indicating value for each 1 min for 4 h. Relating to migration average value (for each 1 min) during 20 min of this record, take the initial value as the reference value, and obtain the maximum diviation (either positive or negative) from the reference value.

6.2.8 Over-Scale Characteristic Test In the case of analog system, irradiate by 1 cm dose equivalent corresponding to approximately 10 times the maximum scale of each indicating range for 1 min. In the case of digital system, irradiate by 1 cm dose equivalent corresponding to approximately 10 times the maximum value of measuring capable range for 1 min.

6.2.9 Temperature Characteristic Test Stand a ratemeter as it is in the working condition under respective environments of -5°C, 5°C, 20°C, 35°C and 45°C in circumferential temperature ([1]) for 1 h or more, and irradiate γ-rays of 1 cm dose equivalent negligible sufficiently in influence of background and counting loss to read out the indicating values. Take the indicating value at 20°C as the reference value, and obtain the percentage of indicating value at above-mentioned each temperature subtracted by the reference value relative to the reference value.

Further, for power source of ratemeter, use a battery described in instruction manual.

Note ([1]) Tolerances of circumferential temperature, in any cases, shall be ± 2°C.

6.2.10 Moisture Resistance Test Let the circumferential temperature ([2]) be at 35°C, stand the ratemeter in the working condition under the environments of 65 % and 90 % in relative humidity ([3]) as it is for 1 h or more, irradiate γ-rays of 1 cm dose equivalent negligible sufficiently in influence of background and counting loss to read out the indicating value. Take the indicating value at 65 % as the reference value, and obtain the percentage of indicating value at 90 % subtracted by the reference value relative to reference value.

Notes ([2]) Tolerances of circumferential temperature shall be ± 2°C.

([3]) Tolerances of relative humidity, in any cases, shall be ± 5 %.

6.2.11 Stability Test for Fluctuation of Power Source Voltage Irradiate r-rays of 1 cm dose equivalent negligible sufficiently in influence of background and count fall, make the power source the rated voltage, its 90 % and 110 % and read out the indicating value at that time. Take the indicating value at the rated voltage as the reference value and obtain the percentage of indicating value at each voltage subtracted by reference value relative to the reference value.

6.2.12 Impact Resistance Test Place a ratemeter on a wooden stand of lauan member of 20 mm in thickness or the like under the ordinary storage condition and after hanging up other side to become 50 mm in height with one side attached on the stand as it is, leave the hand. Relating to each side of front and rear, right and left, after applying impact by each five times for each side in total 20 times according to this method, carry out the indicating error test of 6.2.2.

7. Inspection

7.1 Type Inspection The type inspection shall be of the following items, carry out the tests according to 6., and take the matters complied with the specifications of 4. as acceptable.

(1) Indicating error

(2) Energy characteristics

(3) Directional characteristics

(4) Indicating value fluctuation

(5) Response time

(6) Drift

(7) Over-scale characteristics

(8) Temperature characteristics

(9) Moisture resistance

(10) Stability against power source voltage fluctuation

(11) Impact resistance.

7.2 Delivery Inspection As to delivery inspection, relating to indicating error, carry out the test according to 6. and take the matters complied with the specifications of 4.1 as acceptable.

8. Marking

Ratemeters shall be marked with the following matters on a ligible portion according to easily indelible method.

(1) Name

(2) Type name (only by manufacturer)

(3) Classification

(4) Manufacturing number

(5) Year and month of manufacture or its abbreviation

(6) Name of manufacturer

(7) Label indicating measuring reference point of detector and irradiation direction of radiation at the time of test

(8) Name of nuclide of source used for calibration.

9. Instruction Manual

Ratemeters shall be appended with instruction manual described with at least the following matters:

(1) Type and dimensions of detector

(2) Indicating error

(3) Energy characteristics

(4) Directional characteristics (including directional characteristics by X-rays near 80 keV in effective energy or by γ-rays or ^{241}Am)

(5) Response time or time constant

(6) Irradiation direction of radiation at the time of test

(7) Nuclide name of source and using method (exclusively in the case of appending ray source for test)

(8) Type and number of units of using batteries

(9) Mass and dimensions

(10) Precautions to using.

Attached Table. Irradiation Dose Rate ([4]) - 1 cm Dose Equivalent Conversion Coefficient

Photon energy or effective energy MeV	Conversion coefficient		Conversion coefficient from air absorption dose rate ([5]) (Informative reference)
	Sv/ (C·kg^{-1})	{mSv/R}	Sv/Gy
0.010	0.350	{ 0.090}	0.010
0.015	9.17	{ 2.37 }	0.271
0.020	20.3	{ 5.25 }	0.601
0.030	36.8	{ 9.50 }	1.09
0.040	48.5	{12.5 }	1.43
0.050	55.1	{14.2 }	1.63
0.057 ([6])	58.1 ([7])	{15.0 } ([7])	–
0.060	59.1	{15.2 }	1.74
0.080	58.7	{15.1 }	1.73
0.10	55.7	{14.4 }	1.65
0.124 ([8])	52.6 ([7])	{13.6 } ([7])	–
0.15	50.3	{13.0 }	1.49
0.20	46.7	{12.0 }	1.38
0.30	44.4	{11.5 }	1.31
0.34 ([9])	43.4 ([7])	{11.2 } ([7])	–
0.40	42.6	{11.0 }	1.26
0.50	41.1	{10.6 }	1.21
0.60	40.3	{10.4 }	1.19
0.66 ([10])	40.0	{10.3 }	–
0.78 ([11])	39.4 ([7])	{10.2 } ([7])	–
0.80	39.3	{10.1 }	1.16
1.0	38.7	{10.0 }	1.14
1.25 ([12])	38.4 ([7])	{ 9.91 } ([7])	–
1.5	38.3	{ 9.88 }	1.13
2.0	38.3	{ 9.87 }	1.13
3.0	38.1	{ 9.82 }	1.12
4.0	37.7	{ 9.71 }	1.11
5.0	37.5	{ 9.67 }	1.11
6.0	37.3	{ 9.62 }	1.10
8.0	36.8	{ 9.50 }	1.09
10	36.8	{ 9.50 }	1.09

Notes ([4]) It is the irradiation dose rate in free space.

([5]) It is the absorption dose rate of air in the case where charge particle equilibrium consists in free space, and the conversion coefficient is in accordance with Notification Separate Table No. 4 of the Law Concerning Prevention from Radiation Hazards Due to Radioisotopes etc.

([6]) It is the energy corresponding to equivalent conversion coefficient of γ-rays of ^{241}Am in the case of using 0.2 mm Cu filter (hereafter referred to as the "equivalent energy").

([7]) It is the equivalent conversion coefficient which is the ratio of discharge r-rays to irradiation dose of dose equivalent corresponding to fluence rate distribution.

([8]) It is the equivalent energy of γ-rays of ^{57}Co.

([9]) It is the equivalent energy of γ-rays of ^{133}Ba, in the case of using 0.2 mm Pt filter.

([10]) It is the energy of γ-rays of ^{137}Cs.

([11]) It is the equivalent energy of γ-rays of ^{226}Ra in the case of using 0.5 mm Pt filter.

([12]) It is the equivalent energy of γ-rays of ^{60}Co.

Remark: When the corresponding value does not exist, calculation shall be carried out according to interpolation method.

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